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INFORMATION REPORT

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COUNTRY	East Germany	REPORT	
SUBJECT	VEB Isokond - Description of Wattless Current Capacitors for Low Tension	DATE DISTR.	28 February 1956
		NO. OF PAGES	1
DATE OF INFO.		REQUIREMENT NO.	RD
PLACE ACQUIRED		REFERENCES	25X1
DATE ACQUIRED			

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(FOR KEY SEE REVERSE)

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wattless current
capacitors for low tension manufactured by VEB Isokond, Isolierstoff- und Kondensatorenwerk, Berlin-Weissensee
a general statement of the problems of wattless current, construction of the capacitors, high potential capacitors, mounting and operation of the capacitors, and a list of three-phase low tension capacitors with specificatio

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(NOTE: Washington distribution indicated by "X"; Field distribution by "#".)

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Wattless Current Capacitors

1) Problem of Wattless Current

When transmitting electric power, besides the real current participating immediately in the transmission of electric power, wattless current is arising, too. This wattless current is required for unobjectionable service of many electric units such as transformers, motors etc. It leads, however, additionally other transmission members of the power-way (e.g. transformers), thus preventing their full utilization for transmission of real current.

There are different possibilities to reduce the share of wattless current in such transmission or to suppress it in total. Besides correct load of transformers and motors the most important mean for such purposes is the high current capacitor. The high current capacitor also takes up wattless current but only that which is running in opposite direction to the inductive wattless current of users. In this way the wattless current of users is compensated by means of the high current capacitor, and the above mentioned disadvantageous effects on the transmitting equipment are avoided.

2) Profitableness of Wattless Current Capacitors

The power plants have to meet the above mentioned unfavourable influence of wattless current on the loading capacity of their transmitting equipment by placing, in whichever form, the financial expenses resulting from making available such transmitting equipment on the user's account according to the different types of wattless current rates. When

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compensating the wattless current by means of capacitors the considerable amounts continuously paid for such purposes can be retrenched. For this reason already the installation of a capacitor plant will be redeemed within proportionally short time (in general within 8 to 18 months). The compensation of wattless current, moreover, offers the valuable advantage that necessary extensions of transmitting plants such as erection of new transformer stations etc. can be neglected. For such reasons it is recommended to any enterprise to check their running expenses for electric power with special view to the cost of wattless current contained therein, and to consider the advantages resulting from the installation of wattless current capacitors.

3) Construction of the Capacitors

The beginning development of the construction of capacitors aimed, similar to the transformers, at capacitor units of outputs rated for individual applications. This way entailed large capacitors rated for up to 250 KVar and above and accommodated in stable iron casings. While, however, the production of large transformer units is preferred, due to their better efficiency according to increasing size, this is not true for capacitors. The high efficiency of capacitors amounting to more than 99.5 percents (i.e. losses are smaller than 0.5 percents) is approximately the same both at small and large capacitor units. The production of certain standard types of smaller output, therefore, turned out well, and that for the following reasons:

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The stand-by service is simpler, the danger of failures in case of one unit going wrong is reduced, the heat transfer is more advantageous at smaller units, due to their better ratio between surface and volume of the capacitor, and the production becomes economical. This is why nearly all countries prefer the external connection of smaller units to batteries of higher output.

We are producing wattless current capacitors for low tension and ~~high~~ potential mains, which, according to the capacity required, may be connected to different groups.

The capacitors consist of flat-wound members made of high quality capacitor paper, and impregnated, after being carefully vacuum-dried (see Total View of the Impregnating Plant), in a vacuum process with insulating oil owning special qualities namely as to its resistance against effects coming from the electric field. This procedure secures lowest losses, best puncture strength and long life of the capacitor members. With a view to the very large face of paper contained in every capacitor (several 100 sq.m.) defects cannot be completely excluded in spite of careful quality tests. Therefore fuses are provided for the individual windings within the capacitor taking care for disconnecting, in case of failures, the defective, small winding member only while the capacitor as a whole remains capable of operation, setting aside the reduction of capacity amounting to a very few percents.

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In order to maintain the conditions achieved by the vacuum treatment also during operation the capacitors are, according to special methods, hermetically welded. The connections are led into the casing through also airtightly soldered ceramic bushings. The expansion of oil resulting from changes of temperature is absorbed by the flexible walls of the casing and the gas-vacuum within the capacitor.

Owing to this hermetic casing incidental repairs, occurring very seldom, indeed, cannot be carried out unless in the supplier's factory as such work must be executed, upon opening the unit, under use of special vacuum devices.

Besides the procedure as mentioned above the careful control of all raw materials used is of substantial importance for the foolproofness and duration of life of the capacitors. In our works the characteristic qualities of all raw material received are continuously tested, and the material is not given free for production purposes unless it is meeting all demands.

The finished capacitors are subjected not only to the prescribed tests of voltage, capacity, etc. but also examined as to their behaviour in the event of overload applied and at maximum admissible ambient temperatures. The balance of heat, for instance, is continuously tested by examining off-hand samples of capacitors just produced. Such type-tests permit reliable statements whether the examined type of capacitors will meet, with a view to its duration of life, all requirement.

4) Low Tension Capacitors (Fig.2)

For best relief of the transmission plant it is principally

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practicable to install the capacitors within the distribution line possibly close to the user of the inductive current. According to this in many cases low tension capacitors will be used preponderantly low tension users being connected to standard industrial mains. Particular informations about fundamental principles according to which one has to decide for single, group or central compensation can be gathered from our Connection and Working Instructions for Wattless Current Capacitors to be found on page ____.

Figure 3 shows a wattless current capacitor plant consisting of 12 units of 25 KVar, 380 V, connected in 6 groups of 50 KVar each and serving for collection compensation in a substation of an industrial enterprise.

We are producing such capacitors in three sizes of casing. At rated voltages of 380 V and 500 V these sizes result in three base units of capacities of 8, 16 and 25 KVar. For low tension mains of 220 V these three sizes are of wattless powers of 5, 10 and 15 KVar. Taking regard to the fact that the still existing mains rated for 220 V will be gradually changed to the standard voltage of 380 V the latter types are designed for open circuit and equipped with six terminals permitting their changing over to a mains voltage of 380 V by connecting the three individual capacitors in star connection. This construction also permits to change over the capacitor easily for single phase use as required for welding transformers and other single phase users. The type-designation of such capacitors, therefore, is completed by the added letters "ED" (Einsphasig und Drehstrom = single phase and three-phase current).

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On request the same wiring with six terminals can be provided for capacitors rated for a mains voltage of 380 V and 500 V, too, if such a design is required. Besides the already mentioned single phase use such a requirement may result from the use of the capacitor for individual compensation of a motor to be started by means of a star-delta switch. In such an event the open-circuited capacitor permits an immediate, parallel connection between each phase winding and the appropriate section capacitor (see Fig. 4), thus avoiding difficulties and endangering facts otherwise possibly resulting from star-delta switching. Details concerning such dangers and their avoidance are contained in our Connection and Working Instructions for Wattless Current Capacitors.

The above mentioned wattless current capacitors are produced, according to listed standards and prevailing working conditions, for indoor mounting in dry rooms. In order to meet special working conditions special designs of shock-proof and flame-proof constructions have been made, and the corresponding capacitors are partially already in state of production. The shock-proof capacitors are provided for operation in connection with users exposed to shocks during service such as equipment for removing the overburden or dredging in open cut lignite mines. Such capacitors are produced with capacities of 8, 16, and 25 kVar for three-phase voltages of 380V and 500 V. Flame-proof capacitors are ordered for underground operation in coal and potash mines.

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mine damp are to be reckoned with. The capacities produced amount to 8, 16 and 25 KVar for 500 V three-phase current. According to the hard working conditions at underground service the capacitors are equipped ~~with~~ manufactured casing and suitable for transport and location within mine galleries by means of skid-runners welded to the casing. The terminal box is moisture-proof screwed and constructed according to the protective system of increased safety (VDE 0170, sec.27, par.d). The casing corresponds to VDE 0170, sec.49, "Special Protective System 3". The summary or types and technical data can be gathered from page 15.

High
2) Low Potential Capacitors (Fig.3)

If within the range of compensation of wattless current low potential users, e.g. transformers or larger motors should be compensated, or seems it necessary to transfer the control of the capacitors to the electric power station numerous cases arise in the event of which, under adherence to the fundamental principle to install the capacitors possibly close to the inductive user, the installation of capacitors in the ~~high~~ potential mains will turn out more advantageous.

As high potential mains here the distribution networks of tensions from 2,000 to 30,000 V are to be understood. For such applications we have developed standard capacitors produced with capacities of 33.3 KVar and for voltages of 2 KV, 3 KV and 6 KV. These single phase units are principally suitable for outdoor mounting, too, and permit to fill most different tasks by corresponding combination of the individual sets.

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By means of series connection, series and parallel connection and by connection of corresponding capacitor groups in star and delta circuits the individual units can be composed to capacitor batteries for mains voltages from 2 to 30 KV with capacities ranging between 100 and 1,200 KVar, and, if required, larger groups, too. (As to the summary on wiring of high potential units please see schedule No.6.) The capacitors are insulated against the casing for a rated voltage of 10 KV; therefore they may be mounted, up to a mains voltage of 10 KV, with grounded casing. In the event of higher mains voltages insulated installation of the casing should be provided. In such a case it is occasionally recommended to select, instead of the standard type with two bushings per casing, the type EP equipped with one bushing only and the second capacitor pole connected to the casing, thus saving material and expenses for the second bushing and entailing, in certain cases, a clearer arrangement of wiring. As to the summary on types and technical data concerning high potential capacitors please see schedule No.5.

6) Mounting and Operation

Wattless current capacitors for indoor mounting should be installed in conveniently ventilated rooms in order to secure their unobjectionable cooling. The ambient temperature must not exceed the peak value of +35°C. On extraordinary conditions of temperature in a given case separate ventilation by means of fan should be provided. Any precaution resulting in the reduction of capacitor heat will prolong the duration of life of the unit. Concerning outdoor capacitors the admissible ambient temperature ranges

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between -40 and +40°C whereas the additional rise of temperature resulting from direct irradiation of sun is generally admissible, provided, special regard has been taken to this by corresponding coating.

The capacitors are rated for the tension and frequency as stated on the ratingplate. Attention is to be paid to the wattless power changing in quadratic ratio to tension, i.e. a mains voltage increased by 10 percents entails an output increased by 21 percents. During periods of reduced load, therefore, capacitors should be disconnected in order to avoid increased voltages endangering besides the capacitors other users, e.g. incandescent lamps, too.

Switch sets, feeders and fuses for the capacitor should be rated at least for the 1.5-fold rated capacitor current. The capacitors should be furnished with time-delayed fuses to avoid needless fuse-defects caused by the rush of current when throwing on the load. The switch sets of capacitors are strained by the rush of current at make and by the increased voltage resulting from residual load in case of disconnection to a higher degree than in the event of ohmic load. Hand-operated knife switches, therefore, on principle never should be used. When using them temporarily they should be rated for the 2.5-fold rated strength of current. Capacitors require magnetic switches of special design suitable for this task. The peak of current at make must be limited by prestige resistances, inductivities in shape of magnetic releases or similar presentations. Particularly in the event of frequent connection and disconnection of individual units of larger capacitor batteries connected to a common busbar

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the switch-on conditions are most sensitive and require strict adherence to the above mentioned hints. After disconnection the capacitor retains, in dependence on the phase position at the time of interruption, a tension amounting up to the peak value of rated voltage. For discharging this voltage safely the three-phase low tension capacitors are equipped with two discharge resistances. The power input of these resistances during service is very small. They are rated for discharging the capacitor through them within one minute to less than 65 V, thus preventing any endangering. In case these resistances should be damaged mechanically or otherwise they must be replaced by intact resistances of same ohmic value and output in order to avoid any accidents when contacting the disconnected capacitor. Further hints concerning the connection and operation of low tension capacitors are to be gathered from the Connection and Working Instructions added to each capacitor.

High potential capacitors are built, on principle, for outdoor mounting. The connections required for the individual mains voltages are compiled in schedule 6 on page 20. For switching individual groups connected in parallel to one busbar special switches with resistance prestage (e.g. "Sahnenwerk" type COV) or equivalent attenuators (e.g. expansion switches with preconnected choking coils of about 1 percent of the capacitor output) should be used. The exact rating of the switch devices for larger high potential batteries should be accommodated, in co-operation with the respective designing offices, to the working conditions prevailing for the plant provision is to be made for.

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The discharge of groups of high potential capacitors is generally carried out best through V-connected potential transformers unless the special switches (e.g. "Sachsenwerk" type COV) are bearing built-in discharge resistances grounding, upon disconnection, the capacitor battery through resistances.

It is important to keep the capacitor load thrown on at times accommodated to the demand for wattless current. At single compensation this will be secured without difficulties. When providing group or collection compensation (see our Connection and Working Instructions) corresponding manual or automatic control must be carried out. The most reliable automatic control results from connecting and disconnecting the individual capacitor groups in dependence on the arising capacitive wattless power. The so-called reactance output limiters (make: e.g. Elektro-Apparate-Werke J.W. Stalin), therefore, are working against this principle. The use of such automatic control devices is practicable particularly at larger plants.

At smaller plants or plants with insignificantly varying resistance load in many cases by ingenious arrangement of the capacitors close to individual users or groups of them a solution can be found which will secure a sufficient accommodation of capacitors switched on at times without such control devices.

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Schedule 1

**Three-phase Low Tension Capacitors
with protective coat for indoor mounting**

These capacitors are internally rigidly delta-connected, and the terminal board is equipped with three terminals and two discharge resistances arranged below the connection cap.

Index:	Output: KVar	Rated Voltage: 50 c. pF	Caps- city: A	Rated Current I	De- lay- ed fuse A	Size Scale draw- ing I	Weight kgs
BK-B 380/8 D	8	3x380 V	176	3x12.2	3x25	1	32
BK-B 380/16 D	16	3x380 V	352	3x24.4	3x60	2	54
BK-B 380/25 D	25	3x380 V	550	3x38.2	3x60	3	77
BK-B 500/8 D	8	3x500 V	102	3x 9.25	3x20	1	32
BK-B 500/16 D	16	3x500 V	203	3x18.5	3x35	2	54
BK-B 500/25 D	25	3x500 V	317	3x26.8	3x50	3	77

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Schedule 2

**Low Tension Capacitors of Open Circuit
with protective coat for indoor mounting**

These capacitors contain three internally arranged capacitor groups with insulated lead-out connections. The terminal board is equipped with six terminals permitting manifold applications, e.g. for single phase operation by means of suitable exterior wiring (spot welding machine, welding transformer). It is possible, furthermore, to run these capacitors rated for 220 V in case of future change of the mains to 380 V as star-connected units under this tension, too. Single compensation, moreover, can be provided at star-delta-start of squirrel-cage motors of 380 V and 500 V by direct connection of the windings in parallel to the capacitor groups.

Index:	Output: KVar	Rated Voltage: 50 c.	Capacity: uF	Size acc. Scale	Weight: kgs
Draw- ing I					
BK-A 220/5	ED	5	3x220 V	3x109.3	1
BK-A 220/10	ED	10	3x220 V	3x219	2
BK-A 220/15	ED	15	3x220 V	3x328.6	3
BK-B 380/8	ED	8	3x380 V	3x 55.3	1
BK-B 380/16	ED	16	3x380 V	3x117.3	2
BK-B 380/25	ED	25	3x380 V	3x183.3	3
BK-B 500/8	ED	8	3x500 V	3x 34	1
BK-B 500/16	ED	16	3x500 V	3x 67.6	2
BK-B 500/25	ED	25	3x500 V	3x105.6	3

Fig.7

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Schedule 3**Shock-proof Three-phase Low Tension Capacitors
with protective coat for outdoor mounting**

For special mechanic strains e.g. when installing the capacitors on dredgers, big travelling cranes etc it is recommended to select the shock-proof type whereat also the protective hood for the joints as generally provided for all types against protective system P 33 (DIN 40050) turned out best.

Index:	Output: KVar	Rated Voltage: 50 c.	Capa- city: μF	Rated Current: A	De- lay- ed Scale	Size acc. ed Scale	Weight kgs
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RBK-B 380/8	D	8	3x380 V	176	3x12.2	3x25	1	41
RBK-B 380/16	D	16	3x380 V	352	3x24.4	3x60	2	79
RBK-B 380/25	D	25	3x380 V	550	3x38.2	3x60	3	92
RBK-A 500/8	D	8	3x500 V	102	3x 9.25	3x20	1	42
RBK-A 500/16	D	16	3x500 V	203	3x18.5	3x35	2	72
RBK-A 500/25	D	25	3x500 V	317	3x28.8	3x50	3	94

Schedule 4**Flame-proof Three-phase Low Tension Capacitors
with protective coat for outdoor mounting**

The following flame-proof capacitor types have been developed for underground use in potash and coal mines. With a view to the heavy-duty operation in mines these capacitors are enclosed in reinforced casings (VDE 0170949) equipped with solidly welded-on transportation runners. The design of the connection chamber adheres to the rules of increased safety (VDE 0170, sec.21, par.d), and is equipped with a terminal trumpet for leading-in-rubber cables. Upon one year's trial run for testing the mine-strength the capacitors are approved by the testing mine Freiberg and receive the flame-proofness mark "Sch".

Index:	Output: KVar	Rated Voltage: 50 c.	Capa- city: μF	Rated Current: A	De- lay- ed Scale	Size acc. ed Scale	Weight kgs
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SBK-A 500/8	D	8	3x500 V	102	3x9.25	3x20	1	60
SBK-A 500/16	D	16	3x500 V	203	3x18.5	3x35	2	91
SBK-A 500/25	D	25	3x500 V	317	3x28.8	3x50	3	118

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Schedule 5

**Summary on Types of High Potential Capacitors
with protective coat for outdoor mounting**

Index:	Output: Rated KVar	Dimensions acc. Voltage: to Scale 50 c.	Drawing IV		Weight: kgs
			a)	b)	
BK-A 2/33,3 E	33.3 2 KV AC.	430	250	980	145
BK-A 3/33,3 E	33.3 3 KV AC.	430	250	980	145
BK-A 3/33,3 EP')	33.3 3 KV AC.	430	250	980	144
BK-C 6/33,3 E	33.3 6 KV AC.	430	250	980	145
BK-A 6/33,3 EP')	33.3 6 KV AC.	450	250	980	144

*) One pole of the capacitors is connected with the casing.

The cylindrical joint bolts are dimensioned to 13 mm in diameter. To permit the connection of bushings the joint bolts are equipped with concentric flat joint terminals flat bars can be connected to. (Hole for fastening screw rated for # 12.)